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REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 22, 1922.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1922.

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. HENRY C. WALLACE,
Secretary of Agriculture.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS.

Investigations of deciduous-fruit insects have been carried out under the direction of Dr. A. L. Quaintance as formerly.

THE JAPANESE BEETLE.—Work against the Japanese beetle has been prosecuted as heretofore in cooperation with the New Jersey and Pennsylvania State Departments of Agriculture. Much additional information concerning the life history, habits, and injurious character of the pest has been obtained in the several lines of work, but it has been spreading and threatens to become a pest of first-class and widespread importance.

The Federal Quarantine No. 48, the New Jersey State quarantine, and the Pennsylvania State quarantine have been in effect, the State quarantines supplementing the Federal quarantine for intra-state traffic. As heretofore, the enforcement of State quarantines has been delegated to bureau authorities, who cooperate with the Federal Horticultural Board. Special attention has been given to the inspection and certification of vegetable products. During the season of 1921 some 205,498 baskets of sweet corn were inspected and more than 5,000 beetles were removed from within the tips of the corn during this inspection. This is a marked increase over inspection work done during the previous year and also in the number of beetles found.

Scouting to determine the limits of infestation was carried on throughout the summer of 1921, involving some 400 square miles, with the result that approximately 213 square miles in New Jersey and approximately 57 square miles in Pennsylvania were found to be infested.

In the investigational work on the Japanese beetle, studies of arsenical insecticides have been continued. Although it has been repeatedly demonstrated in the course of the work that ordinary arsenical sprays are not effective against the beetles at the strengths

usually employed, there seems reason to believe that the use of arsenate of lead at heavier doses than commonly recommended will kill from 50 to 60 per cent of the beetles. Other stomach poisons are under investigation, especially metallic cyanids, such as nickel and copper. Attention is also being given to organic chemicals in the hope that a substitute for arsenical insecticides may be found. Contact insecticides against the adults have been experimented with for several seasons, and it has been found that a contact insecticide of sodium-soy bean soap will kill approximately 90 per cent of the beetles. Fortunately this soap can be used on practically all types of foliage attacked without injurious results.

Additional studies have been made of possible methods of destroying the Japanese beetle grubs in the soil. Paradichlorobenzene probably gave the best results against the larvæ in sod. When used at the rate of 300 pounds per acre at a depth of approximately 1 inch, with the drills 4 inches apart, it killed approximately 75 per cent of the grubs. The cost of such treatment is high, and additional studies are being made. Greenhouse soil has been the subject of special investigation, in view of the necessity of grub-free soil for potting purposes in order to avoid danger of dissemination of the grubs in the shipment of potted plants. It was found that carbon disulphid is a cheap and efficient material for fumigating potting soil. For best results not less than 1 pound to a cubic yard of soil must be used, with an exposure of 48 hours at a temperature above 50° F. Soil up to almost any quantity may be treated by this method with assurance that the grubs will be killed. Thoroughgoing experiments to determine the possibility of vacuum and pressure for the destruction of the grubs in the soil have not shown favorable results. Tests of various arsenicals as soil insecticides are under way. Arsenate of lead has proved to be the best and will kill the grubs. Plants vary in their resistance to this treatment and further studies are necessary.

A paper giving detailed information on the feeding habits of the beetle has been prepared for publication, as well as a paper on the feeding habits of the larva. It appears that the insect is changing its habits somewhat from season to season in its new environment. This is especially true of the adult beetle. During the season of 1922 the beetles were excessively abundant in the territory infested 3 and 4 years ago, attacking peaches, apples, grapes, and many other plants, including certain shade trees. There is nothing to indicate that the insect has reached its limit of capabilities in this respect.

Studies are in progress to determine the possibilities of destroying the grubs in the soil by cultural practices as carried out in farming and trucking operations.

Suitable equipment has been obtained for making a detailed study of the effect of the removal of the soil from "balled earth" nursery stock, such as conifers. Unless satisfactory methods can be found to kill the grubs under these conditions, nursery interests will suffer, as it would not be safe to ship balled-earth plants.

The search for parasites of the Japanese beetle in Japan has been vigorously prosecuted.

Some 125,000 Japanese beetles infested with a tachinid parasite have been collected in Japan and forwarded to the Riverton, N. J., laboratory, where the parasites have been liberated. Another tach-

inid or dextiid parasite of the adult beetle has also been found in Japan and in Korea. The agents in Japan are also trying to rear large numbers of a parasitic wasp of the genus *Tiphia* which they hope to send over soon. In Korea an early-season dextiid and *Tiphia* parasites of several species have been found, the introduction of which will be attempted as soon as possible. In order to insure the best handling of these parasites, careful attention is being given to their life history and habits as a basis for propagation in large numbers. In addition to this work in Japan, the parasites of related insects in this country are being studied to see if some of them can be made useful against this pest. Still another parasite will be sent from Hawaii.

PEACH INSECTS.—Work has been continued in the suppression of the plum curculio, brown-rot, and scab of peaches in Georgia in co-operation with the Bureau of Plant Industry and the Georgia State Board of Entomology. Continued improvement in the situation has resulted from this work. The harvest of 1922 was exceedingly satisfactory from the growers' standpoint, and in orchards where the bureau's recommendations for spraying, dusting, and other control operations were carried out the fruit was practically free from curculio grubs.

At the urgent request of peach growers in the Sandhill peach district of North Carolina, peach-pest control work was undertaken the present spring in cooperation with the Bureau of Plant Industry and the North Carolina State Department of Agriculture. The spraying and dusting schedule found so effective in Georgia was put in effect in the North Carolina territory with most excellent results.

Considerable attention has also been given to further tests of paradichlorobenzene for the peach borer under varying seasonal conditions and on trees of different ages. It appears that when properly applied this chemical can be utilized for the destruction of the borer on trees 2 to 3 years of age and over, which materially enlarges its range of usefulness and obviates almost entirely the necessity of worming peach trees. Experiments were made in the fall of 1921 to determine the usefulness of paradichlorobenzene for the destruction of the California peach borer on apricot, prune, etc., in the Santa Clara Valley. The results obtained were very gratifying and give hope that the chemical can be used effectively on this serious pest.

APPLE INSECTS.—Studies of the codling moth have been continued along the lines previously followed in the Yakima Valley, Wash., and Rogue River Valley, Oreg., and additional information obtained. The work under way for several seasons in the Ozarks and in north Georgia has been completed, and in the latter State the temporary station closed. Special attention has been given to experimental work with sprays and dusts in orchards to settle many practical points in connection with codling-moth control, such as the comparative merits of spray guns and rods, best type of power machinery to employ, value of stickers or adhesives in spray solutions, and the like. New questions are constantly arising as to spraying and dusting equipment, insecticides, etc., which are of much practical interest to growers. The introduction of codling-moth

parasites from the East to the State of Washington has resulted in the establishment there of one species at least. Further attention is being given to the matter of spray residues on harvested apples and pears in Washington and Oregon. The work under way in California, as indicated in the last report, was successfully completed and a report issued. A spray schedule was developed, which, if followed by growers, will obviate almost entirely the presence of spray residues on fruit at harvest time.

A number of other apple insects have been under investigation, as apple leafhoppers, apple maggot, etc. Manuscripts have been submitted giving the results of several seasons' studies of canker-worms and the bud moth. Observations are being made on the red-banded leaf-roller, the false red bug, and the apple and thorn skeletonizer, this latter a rather recently introduced pest.

The San Jose scale is again becoming troublesome in certain parts of the country, and has been especially injurious in apple orchards in the Ozarks. Special attention has been given to control of this insect in bearing orchards at the Bentonville, Ark., laboratory, and material progress made. A new dormant-tree spray has been developed, composed of 2 per cent engine oil thoroughly emulsified with potash-fishoil soap, which has been found to be very effective. In view of its cheapness and ease of application, the treatment was largely adopted by orchardists in preference to lime-sulphur wash and over 1,000 barrels of stock emulsion were used in Benton and Washington Counties during the spring of 1922. No injury to trees has thus far been noted from the use of this material as a dormant spray, although in experimental work a spray containing as much as 10 per cent of the lubricating oil was applied. This same spray at weaker strength, as 1½ per cent, applied alone or in Bordeaux mixture, has given good control of the hatching scales and the newly settled young. It was further ascertained that a spray containing 1 per cent of lubricating oil was about as effective as nicotine sulphate in the control of the green apple aphid and far less expensive. In cooperation with the entomologists of the Arkansas Agricultural Experiment Station, careful biological studies of the San Jose scale in the Ozarks are being made, special attention being directed to the factors resulting in its present unusual abundance and destructiveness as compared with conditions in former years.

NUT INSECTS.—As during the previous year, the two laboratories engaged in nut-insect investigations were continued. The one at French Creek, W. Va., gave special attention to miscellaneous insects attacking nut crops, and the one at Brownwood, Tex., continued investigations of insects attacking the pecan. Many important facts have been found, leading to practical results of importance.

GRAPE INSECTS.—The investigations of grape insects under way for several years with headquarters at Sandusky, Ohio, in cooperation with the Ohio Agricultural Experiment Station, have been continued along the lines indicated in former reports, particular attention being given to the grape leafhopper, grape-berry moth, and grape root-worm. The grape-berry moth continues to be an important pest throughout northern Ohio and certain localities in Michigan. Control measures developed by the Bureau have been generally adopted

by vineyardists, and it has been shown that thorough and timely spraying will reduce injury to an extent that high-grade fruit can be produced even in localities where berry-moth infestation is heavy. Tests of the single-spray method continue to show very satisfactory results and growers have thus been able to cut down spraying costs materially. However, in localities where there are unsprayed or improperly sprayed vineyards and favorable hibernating places for the berry moth, two sprayings are necessary for proper control. In vineyards where the berry moth, grape leafhopper, and grape rootworm coexist, and where berry-moth damage is comparatively light, it has been demonstrated that by advancing slightly the date of application for the second brood of the berry moth, a schedule of applications can be adopted which will treat all three pests by the same spray application. Major attention at present is being given to a careful study of several species of grape leafhoppers which are just now on the increase in the territory under discussion. Tests of magnesium and calcium arsenate have shown that these substances are not as satisfactory as lead arsenate for application on grapes on account of danger of injury to foliage and fruit. While calcium arsenate has given satisfaction on Concord grapes, it produced injury on certain other varieties. Tests of casein in various spray mixtures were begun in 1919. Our experience indicates that while the spray has good adhesive qualities, it does not spread over the surface of the berry as readily as when resin-fishoil soap is used. A small amount of soap added to the casein-Bordeaux-lead spray seems to increase the spreading qualities of the spray, however.

Studies of the grape mealybug under way in California have been interrupted on account of the large mortality of the insect due to season and parasitism. The experimental work therefore did not show very decided results. Dormant spraying with a petroleum oil emulsion gives excellent results in destroying the insects and is the present recommendation for this pest. Experiments with paradichlorobenzene in the control of the grape *Phylloxera* are promising.

INSECTICIDE INVESTIGATIONS.—Investigations of miscellaneous insecticides have been continued. Attention has been given to a study of the insecticidal constituents of plants, and in cooperation with the Bureau of Plant Industry a paper has been prepared on plant insecticides. In this investigation 232 preparations from 59 species of plants were tested against a total of 28 species of insects. In all, 260 species of plants have been considered, only about 5 per cent of which, however, can be regarded as containing efficient insecticides.

In the work with contact insecticides in cooperation with the Bureau of Chemistry progress has been made, and manuscript giving results obtained to date has been prepared. Further studies are under way of insecticides from petroleum, many oil fractions and by-products of which have been and are being tested in regard to their availability as contact insecticides. In cooperation with the Chemical Warfare Service of the War Department and with representatives of the Federal Horticultural Board, experiments are in progress with numerous toxic gases to determine their availability for use against insects.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

- This project has been continued throughout the year under the supervision of A. F. Burgess, with headquarters at Melrose Highlands, Mass.

At the beginning of the fiscal year the work was resumed with an appropriation of \$400,000, while \$500,000 was really needed to check the continued spread of the gipsy moth in New England and to follow up the exterminative measures that had been inaugurated in the large infested area in New Jersey and in the small colonies in New York State. An appropriation of \$600,000 was asked for the fiscal year 1923, with a request that \$100,000 be made immediately available. It was expected that this \$100,000 would be available by March 1, so that it could be used to finish up the scouting and spraying work in the spring, thus completing the plan of work that had been made for the year. This fund was not available, however, until May 11. Prior to that time it became necessary to reduce the force and to change completely the plan of field operations. In April the entire force would have had to be dropped had it not been possible for a number of the States to come to the rescue at the critical time and finance the work temporarily. In Maine, New Hampshire, and Vermont scouting work was carried on as planned, but the cleaning work in the towns immediately inside the border had to be abandoned on account of lack of funds. In Massachusetts and Connecticut more infestation was found than was anticipated, but shortage of funds at the time when they were most needed made it impossible to scout the area that should have been covered. In addition to this work that had to be neglected, it was not possible to make a thorough examination of a number of towns in eastern New York that should have been inspected, and no cleaning work was done in any of the towns in Massachusetts or Connecticut in accordance with the original plans. All sizable colonies in a strip 25 miles wide along the western border were sprayed, and a considerable area was treated farther east. The results were seriously interfered with by the abnormally heavy rainfall during June.

On July 1, 1922, the Federal Horticultural Board placed under quarantine for the gipsy moth additional areas in New England as follows: Maine, 346 square miles; New Hampshire, 46 square miles; Vermont, 332 square miles; Massachusetts, 1,918 square miles; Connecticut, 1,003 square miles; making a total of 3,645 square miles. Several towns were released from quarantine, as no infestation was found at the time they were examined; there were 3 in Maine, 2 in New Hampshire, and 2 in Vermont.

In New York a colony of the gipsy moth was found at Greenport, Long Island, and a small colony was reported at Patchogue, Long Island. These have been carefully treated and sprayed. The small colonies reported last year in five localities were carefully inspected and treated, and no infestation has been found this year. Most of these colonies resulted from infested trees that had previously been shipped from the Somerville, N. J., area. They must be carefully watched and treatment applied next year, should any infestation be found. It is believed, however, that the insect has been exterminated in these localities. The work in New York has been conducted in close cooperation with the State bureau of plant industry.

In New Jersey all the isolated colonies, nine in number, have been given careful attention and no infestation has been found in any of them. These areas will be rescouted next year and treated if infestations develop. Scouting the woodland north of Somerville was begun in the fall and the whole area was well covered by late spring. Insufficient funds made it impossible to do cutting work on several river-bottom areas that were difficult to treat or spray successfully, but otherwise the program was carried out as planned.

Spraying was conducted on a larger scale than usual in New Jersey, but was much less effective than was expected, on account of almost continuous and heavy rains during May and June. Great difficulty has been encountered in this State in securing competent men who could be trained to carry on the work. The infested section of the State is devoted largely to manufacturing and business enterprises, and few competent men can be found who are interested in active outdoor work. It has been necessary to train large numbers of men drawn from the country districts in New England, and at times it has been extremely difficult to maintain an adequate and efficient force. The work has resulted, however, in a sharp decrease in the number of caterpillars over the previous summer. The area over which the infestation extends is slightly larger than last year, but in no place in New Jersey was there any defoliation by the gipsy moth this summer, and the results for the year on the whole have been encouraging.

New Jersey has expended \$125,000 during the year, and close co-operation has existed between the State department of agriculture and the bureau. A quarantine of the infested area has been maintained by the State, and all shipments likely to carry the gipsy moth to points outside have been inspected and certified before being allowed to proceed. The same arrangements have been very effective in the State of New York, where a few small areas are infested. No trace of the insect has been found in the area previously found infested in Pennsylvania.

A limited amount of scouting has been done along the border of the brown-tail moth infestation, and as a result of this work there has been a heavy decrease in the infested area during the year. Two thousand three hundred and forty-two square miles have been released from quarantine in the following States: Maine, 323; New Hampshire, 917; Massachusetts, 64; Rhode Island, 1,038.

The maximum spread of the brown-tail moth was in 1914, when over 38,000 square miles was infested, including portions of all the New England States and eastern end of Long Island, New York. Now this insect is known to be present only in Maine, New Hampshire, and Massachusetts, and the maximum infested area has been reduced 67 per cent.

The area in New England infested by the gipsy moth and the brown-tail moth has continued under quarantine and all shipments likely to carry these insects have been inspected and certified before being removed from the infested area. This has been done to safeguard other sections of the country from long-distance spread of these insects.

One expert assistant has been sent to Japan and one to Europe to study gipsy-moth conditions and to secure and ship parasites and other natural enemies to America. It was also desired to study the

fluctuations of the insect and the injury caused by it in its original homes in the hope that this knowledge may be helpful to us. In Japan a survey was made of the region easily reached from Yokohama, and investigations were also made in the vicinity of Sapporo on the island of Yezo. So few gipsy moth were found in the latter region that it seemed best to confine the greater part of the work to the territory near Yokohama, where several fair-sized infestations were available. Biological studies were taken up at this point and several shipments of parasites have been forwarded to the gipsy moth laboratory in Massachusetts. Owing to failure to have these shipments properly iced throughout the entire trip, they arrived in poor condition.

The European investigations consisted of a survey of conditions of gipsy-moth infestation in France, Italy, Spain, and Germany. The infestation in Germany this year is practically negligible, and the same is true of Austria and Poland, the latter country having been visited in the hope of securing natural enemies of the gipsy moth. Very little parasitic material has been received from Europe this year as a result of this investigation, but data concerning conditions have been secured and considerable work that is of particular value in the parasite investigations has been done in the museum at Berlin and elsewhere.

The parasites and natural enemies of the gipsy moth and brown-tail moth that have already become established in New England have been found in large numbers in some localities. The great difficulty appears to be that all the different species concerned are not abundant enough over a wide area so that a reasonable measure of control results. Colonization work was continued and areas in all the infested States received plantings of parasites that did not occur there heretofore. There still remains a considerable amount of this work to be done before all of these beneficial species are liberated throughout the infested area.

The temperature during the winter was extremely low in many sections of New England. On this account an enormous number of gipsy-moth egg clusters failed to hatch. This has resulted in a decreased amount of defoliation from that of the previous year, particularly in localities where the egg clusters were laid high on the trees and were not protected during the winter by snow or ice. Considerable defoliation by the gipsy moth has been observed in New Hampshire, south of Lake Winnepesaukee, and in the southwestern section of Maine. In parts of this region the trees were denuded over large areas. In many of these localities the wilt disease destroyed many of the larvæ and parasites were abundant. There has been less defoliation in Massachusetts and Rhode Island than during the previous year.

CEREAL AND FORAGE INSECT INVESTIGATIONS.

W. R. Walton has continued in the leadership of the important work of this section.

EUROPEAN CORN BORER.—In August, 1921, subsequent to my report of last year, the corn borer was discovered on the islands in Lake Erie immediately opposite Sandusky, Ohio. Scouting operations promptly showed that the insect had become established in small

numbers along the entire shore of the lake in New York, Pennsylvania, and Ohio. In Michigan it was also found in a few townships along the lake just south of Detroit.

How the corn borer became established in this important territory is not definitely known, but there is circumstantial evidence that the moths may have been blown by the wind across Lake Erie from the intensely infested area immediately south of London and St. Thomas, in Ontario, Canada. The records of the Weather Bureau show that the prevailing winds blew rather constantly from that region during the flight season of the moths in 1921. In order to study the insect in this new area, a field laboratory has been established at Sandusky, Ohio, for the purpose of learning all the important facts which may in any way be used to combat the pest in this region. Stations as centers of scouting and certification of crops have been established at Cleveland and Toledo, Ohio.

While injury to crops by the corn borer in the newly infested territory in Ohio and Michigan is not likely to become very evident for some time, perhaps not for several years, nevertheless the close proximity of this new infestation to the principal corn belt of the country makes it practically certain that the pest will reach that region by flight or otherwise within the next few years.

The work of introducing the natural enemies of the corn borer from Europe has made rapid strides during the year. Experts located at Hyères, southern France, have been almost constantly collecting and shipping insect parasites of the corn borer to America, where these have been assorted and reared, to be subsequently liberated in large numbers in the heavily infested regions of New England. More than 500,000 specimens of a single species of parasite have been liberated in this manner during the summer of 1922, and thousands of individuals of several other kinds have also been liberated in this region. The present plans of the bureau include the continuation of this work in order to insure, where possible, the establishment of all available beneficial insect enemies of the pest before it becomes widely distributed throughout the United States. With this in view, what promise to be successful steps have been taken to establish one species of these parasites on native corn borers in the South Atlantic and Gulf States, so that this enemy may be present and ready to attack the pest in case the European corn borer should spread to those regions.

Many other lines of investigation are being followed out to find if possible sound means of control. Some of these are modifications of farm practice, such as plowing under or burying infested stubble, weeds, etc., the feeding of infested forage to live stock, the effect of placing it in silo, and its preparation by machinery for ensilage. The use of chemicals as weed killers, to control the insect in weed areas, is being investigated with some success. The variation in the time of planting corn and the selection of varieties and the use of trap crops are being studied, and insecticides are being investigated as well. Every possible line of research which may lead up to means of control is being followed up.

A reduction of \$75,000 which was made in the appropriation for the fiscal year ending June 30, 1923, will render difficult the proper carrying on of all the important work which ought to be done, especially in view of the comprehensive scouting and other operations

which will be necessary under present conditions. Some of the States involved have agreed to aid in this work, and New York has in fact appropriated \$25,000.

The Dominion of Canada is heartily cooperating in this investigation.

THE SORGHUM MIDGE.—Since the publication in 1911 of a preliminary report on investigations of the sorghum midge, it has been apparent that this pest is the limiting factor in the production of the grain sorghums in southern and western Texas and elsewhere. Investigations were begun two years ago, and we have now a simple and effective preventive method, based on agronomic and cultural practices, which promises almost complete relief from this formidable and wasteful pest. This will soon be given out to the growers.

THE SO-CALLED GREEN BUG.—The entomologists of Kansas, Missouri, and Texas have been cooperating with the Federal field-crop insect investigators in conducting a survey in order to determine the status of the green bug in the region most subject to its ravages. The results of this survey have shown conclusively that major outbreaks of this destructive wheat pest are dependent exclusively on the presence of volunteer grain, which permits uninterrupted breeding of the pest throughout the year. In northern Texas, where dry conditions prevailed last fall and no volunteer grain was available, the green bug was almost absent. In northern Oklahoma and south-central Kansas, however, where conditions permitted volunteer grain to flourish, there appeared destructive local outbreaks of the insect, which did considerable injury, especially to oats. It is proposed to make an annual survey like this and to forecast general outbreaks of the green bug for some months in advance. The remedy for the situation, however, obviously is for farmers to abandon the practice of allowing volunteer grain to spring up and become permanent breeding places for this pest.

GRASSHOPPERS.—As stated in last year's report, the last session of the Sixty-sixth Congress ordered an investigation of methods for the control and destruction of grasshoppers, appropriating for this work the sum of \$40,000, which became available on July 1 last. During the past year it has been found unnecessary to use more than \$20,000 of this money. The results of the activities under this appropriation have been the saving of crops in North Dakota and Wyoming alone in an amount to exceed \$600,000. In the former State normal conditions now prevail. In addition to this, much work of a similar character has been done in Oregon, California, Arizona, and other States. An expert has also been stationed in northern Texas who has learned much that will be useful in case of grasshopper increase. At the present writing outbreaks of large proportions are in progress in Montana and Wyoming. The bureau foresaw this and established a field laboratory at Billings, Mont., in April last, and has four experts on the ground busily engaged in aiding farmers and extension workers in combating the pest. The Federal, State, and Canadian entomological forces have formed an informal organization to aid in the work of controlling grasshoppers by adopting uniform plans of procedure.

✓ **THE HESSIAN FLY.**—Thanks to the work of State and Federal entomological workers, the wave of Hessian-fly infestation of 1920-21 has passed over the winter-wheat belt and has waned without inflict-

ing major injury to the crop. The results of recent surveys show the insect to be present in minimum numbers everywhere except in small areas where local conditions or slack farm practice have given it refuge. Progress has been made during the year in the study of the principal parasites of the Hessian fly, and publications reporting this work are in press.

THE ALFALFA WEEVIL.—Further progress has been made toward the economical control of the alfalfa weevil by dusting with arsenicals which will further simplify control and obviate the necessity of hauling water for spraying purposes in the arid regions where this pest occurs. It is hoped to publish this method in the near future. One of the parasites of the alfalfa weevil, imported from Europe before the war, is doing good work, and the weevil is being studied in south France with a view of importing other helpful parasites.

STORED-PRODUCT INSECT INVESTIGATIONS.

Investigation of this group of insect injuries has continued under Dr. E. A. Back's leadership.

INSECTS ATTACKING GRAIN AND GRAIN PRODUCTS.—The research laboratory at Orlando, Fla., established for the study of the biology of the corn or rice weevil under semitropical conditions, was discontinued during the past year. The Florida investigation yielded new and valuable scientific data that have appeared in printed form. The work has been moved northward to Washington, D. C., where similar studies of all grain pests are being made under different conditions of temperature and moisture.

The laboratory at Thomasville, Ga., has been continued along the same lines as mentioned in my last report. While State and Federal officials still estimate that weevils destroy approximately 10 per cent of the corn crop of the South, the work conducted from Thomasville as a center, and in cooperation with the Georgia Agricultural Experiment Station, has greatly improved conditions in the area concerned.

BEAN AND PEA WEEVILS.—The biological studies of bean and pea weevils and the effect of cold storage and fumigation as remedial measures have received further attention at the Alhambra (Calif.) laboratory, but special emphasis during the past year has centered upon a study of varietal susceptibility and the relation of date of planting and harvesting to the degree of field infestation. Satisfactory progress has been made and reports are already available in printed and manuscript form.

INSECTS ATTACKING MEAT.—Our investigation of insects attacking meat, and particularly of the ham skipper and larder beetles, has been continued as a major project. Meat valued at over \$1,000,000 is annually condemned by the inspectors of the department on account of infestation by these insects. Assistance is being given the Bureau of Animal Industry at its Beltsville farm along lines of control which alone make possible the conduct of important experiments in meat curing, etc. Much information new to science is being secured. A paper summarizing important biological facts concerning the ham skipper has already been published.

DRIED-FRUIT INSECTS.—An investigation of insects attacking dried fruits has been started during the past year with headquarters at

Fresno, Calif. At the time of this report the work has hardly passed its preliminary phases.

EXPERIMENTS WITH WOODS OF INSECTICIDAL VALUE.—The experiments to determine the value of cedar chests, mentioned in my last report, have been brought to a satisfactory conclusion, and results are now available in published form. It has been found that while well-made cedar chests can not be depended upon to kill adult clothes moths and their eggs, nor the half-grown to full-grown larvæ, they can be depended upon to kill the newly hatched and very young larvæ. At the request of manufacturers, other species of cedar, redwood, camphor, and other woods are receiving similar attention.

HOUSEHOLD INSECTS.—Insects troublesome in homes, including particularly the bedbug, clothes moths, carpet beetles, and silverfish, have continued to receive attention. During the past year special attention has centered upon the biology of clothes moths as affecting the brush and fabric industries. Valuable information has been obtained. The work has not received the attention it deserves, through lack of funds. A special bulletin dealing with fabric pests has been prepared and submitted for publication.

COLD STORAGE FOR THE PREVENTION OF LOSS BY INSECTS.—An investigation into the effect of cold-storage temperatures upon the life of insects in commodities has been started and already is yielding beneficial results. This is a relatively new field of investigation. Experiments already completed indicate the value of cold storage for the destruction of bean and pea weevils in beans. All stored-product pests are being made the subject of investigation in connection with cold temperatures. A progress report has already been read before the American Association of Ice and Refrigeration, which has offered the hearty cooperation of its members.

FUMIGATION WORK.—The investigation of the value of fumigation in the prevention of losses through insect attack in warehouses continues to be an important phase of the work of the bureau. Industries throughout the country are calling upon the department continually for information regarding the protection by fumigation of stocks of raw wool, grain, grain products, beans, cowpeas, candies, meats, hides, brushes, fabrics, furniture, and a long array of other susceptible raw and manufactured products.

INSPECTION AND INTELLIGENCE SERVICE.—The cooperation with the Army and Navy has been continued in the way indicated in my last year's report. This service during the past year has been directed more largely toward furnishing the Army and Navy with information regarding the susceptibility of various fabrics to moth attack. This work has been conducted at Washington, the laboratory maintained during and since the war at the Army Supply Base at Brooklyn, N. Y., having been discontinued during the past year.

TROPICAL AND SUBTROPICAL FRUIT INSECTS.

This work has been carried out under the direction of Dr. A. L. Quaintance, in cooperation, in certain cases, with the Federal Horticultural Board.

INSECTS AFFECTING CITRUS FRUITS IN CALIFORNIA.—The experiments under way for the control of the citrus red spider at the Alhambra

station continued through the growing season of 1921 and confirmed earlier conclusions of the superiority of a distillate cresylic acid soap emulsion spray. Further progress was made in the investigation of liquid hydrocyanic-acid gas.

In the southern San Joaquin Valley, in cooperation with the entomologist of the California Fruit Growers' Exchange, experiments were made to determine the comparative merits of dusting and spraying for the citrus thrips. The dusting method was found to be decidedly inferior to spraying.

CITRUS-FRUIT INSECTS IN FLORIDA.—At the Orlando, Fla., station work on the rust mite has been continued throughout the year. This project has proven to be a most intricate one, as it has been very difficult to determine the host plants of the mite or satisfactorily to study its life history. Methods for rearing the rust mite, however, have now been developed and new facts relating to its life history discovered which bear directly on methods of control. Several forms of sulphur have again been tested against the mite, and the merits of sulphur dusts in comparison with liquid sulphur sprays determined. Continued progress has been made in the use of Bordeaux-oil emulsion spray for the simultaneous control of citrus diseases and insects, as mentioned in the last report, the work being carried out in cooperation with the Bureau of Plant Industry of this department. Experiments are in progress to develop an adhesive for sulphur, so that if possible it will remain on citrus foliage a much longer period than at present.

INVESTIGATIONS OF INSECT-KILLING FUNGI.—Studies of insect-killing fungi in Florida, especially in relation to their value in the control of citrus insects, were made. Further information has been obtained concerning the fungus diseases of the citrus mealybug. This knowledge will be of distinct advantage to growers, and it is hoped will save them material expense by eliminating the very unsatisfactory remedial measures employed in the past. While the fungus has not as yet been cultivated on artificial media, it can be disseminated by means of distributing infested insects. The mealybug can be reared in quantity on potato sprouts, infected with the disease, and readily distributed to citrus growers. As stated in the last report, fungus parasites of the rust mite have been discovered and further knowledge concerning them secured. It is believed that one of these fungi can be grown artificially and thus be utilized at times when it will do most good. The fungus will supplement the use of sulphur sprays, especially in early spring, when for any reason these treatments can not be given. Further experiments in the use of fungus parasites of the white fly and purple scale have shown that by spraying with a spore solution, largely during the crawling stages, a mortality of about 85 per cent can be obtained if the host plant is in some way protected from rains after treatment. The discovery of the desirable stage of the insects at which to make the application of the spore mixture points out the need of a medium which will serve to stick the spores to the leaves and insects in spite of rains.

INSECTS AFFECTING MANGO, GUAVA, AND OTHER SUBTROPICAL FRUITS.—Investigations of these insects have been continued, with headquarters at Miami, Fla. Biological studies of the avocado white fly, *Trialeurodes floridensis*, have been completed. Various parasites have been found which attack the species, some of which have been

studied. An efficient spray schedule with insecticides has been determined for the control of this pest. Much additional information concerning the life history of the pyriform scale, *Protopulvinaria pyrifomis*, a pest of avocado trees, has been obtained and a report on this work will be prepared in due time. Particular attention has been given to experiments in the control of the papaya fruit fly, *Toxotrypana curvicauda*. Several acre plats of papayas have been under observation where various methods of treatment were in progress. The tests have included the use of poisoned baits, barriers, bagging, various oils, etc. Several bulletins reporting on the work of this project have been issued during the year, as the "Avocado red spider"; "The avocado, its insect enemies and how to combat them"; "Insects injurious to the mango," etc. Experiments are under way at Homestead, Fla., in developing control for the avocado mealybug, also known as the coconut mealybug (*Pseudococcus nipae*). This is a serious pest of the avocado in certain regions.

INVESTIGATIONS OF THE MEDITERRANEAN FRUIT FLY AND THE MELON FLY.—The work during the past fiscal year at the bureau's laboratory at Honolulu, Hawaii, may be divided into three general parts, namely, plant quarantine enforcement, Mediterranean fruit-fly parasite investigations, and methods of control of bruchids attacking the algaroba bean.

The enforcement of plant-quarantine regulations is done in cooperation with the Federal Horticultural Board, and consists mainly of inspection of fruits and vegetables for shipment to the mainland and supervision over plantations and packing sheds. Details of this work will be found in the report of the chairman of the Federal Horticultural Board.

The fruit-fly parasitism investigation has consisted chiefly in obtaining daily records of parasitism by each of four species of introduced parasites. These records have been summarized and will show the amount of control exerted by these parasites and the degree of infestation of various fruits by the fly.

Four species of bruchid parasites have been reared and liberated. They were brought from Texas to Hawaii in July, 1921, with the result that one of them (*Lariophagus texanus*) has been well established in the field, having been recovered from many localities. Much information has been secured on the degree of control exerted over Bruchidae in algaroba beans by an egg parasite, *Uscana semifumipennis*, and a larval parasite, *Heterospilus prosopidis*, which have been in Hawaii for some years.

INVESTIGATIONS OF FRUIT FLIES AND OTHER TROPICAL AND SUBTROPICAL FRUIT INSECTS IN THE CANAL ZONE.—Work has been continued at this field station. Close survey is maintained of injurious insects of the region, especially to detect those recently established. Particular attention was given during the year to the avocado weevil, *Heilipus perseae*, and the avocado-seed insect, *Stenomoma catenifer*. The citrus black fly, *Aleurocanthus woglumi*, has received major attention among the citrus insects, and data are available for a second report on this important pest, dealing with biology and control. The insect is continuing to spread and constitutes a dangerous source of introduction into the citrus States. The insect enemies of the mango and papaya and the coconut palm have been studied. Attention has constantly been directed to locating as many fruit flies as possible,

but thus far only four species have been obtained. No fruit flies have been bred from avocados, nor has any suspicious fruit been seen.

STUDIES OF GREENHOUSE INSECTS.—The strawberry rootworm, which is a serious pest of roses under glass, has continued to receive a large amount of attention, the work being done in cooperation with the Pennsylvania State Department of Agriculture, with headquarters at Doylestown, Pa. The life history of the pest has been fairly well worked out and experiments in control have progressed to a point to warrant the issuance of recommendations. Fumigation with hydrocyanic-acid gas at the rate of $1\frac{1}{2}$ to 2 ounces per 1,000 cubic feet of space is not only suitable for a single unit type of house, but by using heavy muslin curtains the gas may be confined to any section of an open-range house. A number of open-range houses, involving 33,000 rose plants, have been fumigated consecutively at the above rate with a mortality of beetles of about 97 per cent, and no injury whatever to the plants was to be noted from the treatment. It has also been ascertained that the rose beetle can be reduced to a negligible quantity by keeping beds free from mulch, manure, and dead leaves during the winter months if persistent hand picking of the beetles is resorted to during the latter part of the summer. Further studies of the bulb mite, *Rhizoglyphus hyacinthi*, have been made, including tests of numerous insecticidal materials. Paradichlorobenzene proved to be most effective in killing the mites. During the fiscal year studies of the greenhouse leaf-tyer have been concluded and a control program worked out, involving a combination of remedies directed progressively against the several stages, beginning with the adult.

In cooperation with the superintendent of the United States Botanic Garden, important experiments have been carried out to determine the practicability of frequent fumigation of greenhouses with hydrocyanic-acid gas in order to keep the greenhouses free from such common insects as white flies, etc. No permanent injury followed, and the houses were kept virtually free of pests by the treatment given. The results are of much importance to florists as indicating the desirability of adopting the practice of frequent fumigation with reduced strengths of gas as a means of keeping under subjection their injurious insect pests.

THE CAMPHOR SCALE.—Progress has been made in the investigation and control of the camphor scale, *Pseudaulnuxia duplex*, in cooperation with the Louisiana State Department of Agriculture and the administrative authorities of the city of New Orleans. The distribution of the insect was ascertained to be more general than anticipated at first, demonstrating the impracticability of an eradication program. Special attention was given during the year, with funds supplied largely by the State of Louisiana and the city of New Orleans, to large-scale spraying operations to protect valuable shade trees along the streets and in the parks. This work served as an object lesson to many citizens in New Orleans, and, along with other educational effort in progress, it is believed will serve to induce property owners to undertake spraying operations to protect the trees on their own account. The camphor scale has also been found at Hattiesburg, Miss., and quite recently at Grand Bay, Ala. These outbreaks have been investigated and proper State authorities advised of the occurrence of the insect within their States. Begin-

ning the latter part of the fiscal year, when Federal funds became available, a laboratory for a careful study of the camphor scale was established in New Orleans.

VEGETABLE AND TRUCK-CROP INSECT INVESTIGATIONS.

Work on this project has continued under the direction of Dr. F. H. Chittenden. The great economic importance of the Mexican bean beetle, its sudden appearance, and rapid dissemination in the Southern States have caused a large portion of the work on this general project to be devoted to it as a subproject.

THE MEXICAN BEAN BEETLE.—At the beginning of the fiscal year (July 1, 1921), the Mexican bean beetle was known to be present in 83 counties of the 5 States of Alabama, Georgia, Tennessee, South Carolina, and Kentucky. Continued scouting during late summer disclosed its presence in 111 counties in 6 States, North Carolina being added to the infested list. Everything points to the fact that the beetle is even more at home in its new environment and is more prolific and more destructive than in the West and Southwest. No scouting to follow the insect's spread during the early summer of 1922 has been possible, but reports of injury indicate that the beetle passed the winter successfully over most of the territory infested last year. The largest number of complaints came from the northern part of the previously infested area, indicating that a rapid spread to the north may be expected. Growers are now complaining of injury by the bean beetle in districts in which the insect could be found only by careful inspection last season. Extensive field experiments with most available insecticides have been continued in cooperation with the Alabama Agricultural Experiment Station. It appears that the application of arsenicals to bean plants in the southeastern United States is more hazardous than in the West and Southwest. A commercial basic lead arsenate, used as a dust or as a wet spray, at the rate of $1\frac{1}{4}$ pounds to 50 gallons of water, ranks first among arsenical applications. Standard lead arsenate is too injurious to bean foliage. Calcium arsenate and zinc arsenite are injurious when used as dusts undiluted. Calcium arsenate, however, can be used effectively and with relative safety as a dust when diluted with 9 parts of hydrated lime. The insect is being carefully studied in the field. In 1921 a maximum of four generations was obtained and in this section the insect requires at least two generations to maintain itself, while in the West and Southwest one full generation and a partial, or smaller, second generation are the rule. Experiments have been successfully performed to determine the flight of the beetle. Marked beetles have been taken 5 miles from the point of liberation within a few days. The beetle migrates to woodlands and spends the winter under pine straw and leaves in protected places, a high percentage of survival having been noted. Of new host plants, cowpeas, beggar weed, alfalfa, and sweet clover are notable, beggar weed seeming actually to be preferred to other hosts than the garden bean. A substation has been established at Thomasville, Ga., in cooperation with the Georgia State Board of Entomology, for the study of the insect under extreme southern conditions. A hibernation cage containing 18,000 beetles was placed on Lookout Mountain, Tenn., and interesting comparisons have been

gained between these rather severe conditions, which correspond to a sea-level latitude much farther north, and conditions at Thomasville, Ga., near the Florida line. It seems probable from these studies that the Mexican bean beetle will be able to extend its range over a very large part of the continental United States. Careful studies have been made of the possibilities of natural control. A number of new predacious enemies have been observed, but none has been effective. An expert is engaged in searching for parasites of the insect in Old Mexico.

OTHER INSECTS INJURIOUS TO BEANS AND PEAS.—Work on the control of the pea aphid was continued in California, with especial attention to cannery peas. Nicotine dust was found impracticable because of unfavorable weather conditions, but spraying proved satisfactory, the formula of three-fourths pint of nicotine sulphate and 8 to 10 pounds of soap to 100 gallons of water being more effective than the formula previously used, i. e., 1 pint nicotine sulphate and 4 pounds soap. With the use of a large, power-driven outfit covering 6 rows at a time, 12 acres a day were covered, and probably 18 acres a day can be reached with some improvements. The total cost of spraying, using 100 gallons to the acre, was about \$2 per acre for material and labor. Life-history studies of the beet army worm (*Laphygma exigua*) on peas show a possible maximum of 5 generations a year in southern California, although ordinarily only 4 occur. Although the young worms feed inside the terminal clusters under a weblike covering, making it difficult to reach them with a spray, a satisfactory method of control was obtained by spraying with lead arsenate, 3 pounds to 100 gallons of water. Work on the bean fly or seed-corn maggot has been the subject of research in New Jersey for several years past and has just been completed, embracing a thorough study of the biology and life history and a knowledge of its breeding habits during the summer months. The bean leaf-beetle and bean aphid are also being studied in different regions.

SWEET-POTATO WEEVIL ERADICATION AND CONTROL.—The sweet-potato weevil eradication campaign in Alabama, Mississippi, Georgia, and Florida is continuing as heretofore, and the expected progress in Baker County, Fla., and Charlton County, Ga., is being made, the number of infested farms and the infestations having been lowered to such a degree that the large commercial areas surrounding are now no longer threatened. All sweet potatoes on the infested properties are carefully checked and disposed of under the supervision of inspectors. Although no weevils have been found in Charlton County during the past year, measures are being continued on all suspicious properties, and the systematic inspection prevalent over the entire area is being facilitated by better cooperation with the growers than ever before. New projects in Polk and Hillsboro Counties, Fla., based on different plans of eradication, are being followed. It is as yet too early to give any definite information on results. With the elimination of the weevils from the three districts above mentioned, the State quarantine forces should be able to protect the sweet-potato industries of their respective States. In Alabama no weevils have been found in the area formerly known to have been infested. In Mississippi very sat-

isfactory progress is being made in Pearl River, Hancock, and Harrison Counties. New infestations, however, have developed in Jackson and George Counties. The hearty and thorough cooperation of the plant boards of Alabama, Mississippi, Georgia, and Florida has materially facilitated the progress of the eradication campaign.

INSECTS DESTRUCTIVE TO CABBAGE AND RELATED CROPS.—Lead arsenate and Paris green sprays and laundry soap added as a spreader or "sticker" for the control of the common cabbage worm have proved effective. Preliminary experiments were made with nicotine dust for the flea-beetles which are specific enemies of cruciferous plants in Louisiana, with encouraging results. Nicotine dust was also applied effectively in the District of Columbia and vicinity and in New Jersey for cabbage flea-beetles, with the result that it killed all with which it came in contact, but, since these insects are extremely active and hop and fly readily, it is difficult to give a definite statement as to results. The various plant-lice or aphids which attack cole crops, including the cabbage aphis, turnip aphis, and spinach aphis, have been found to yield to dusting by nicotine, which kills a very high percentage.

INSECTS INJURIOUS TO POTATO AND RELATED CROPS.—Experiments on the potato leafhopper, the cause of potato "hopperburn," have been continued under abnormal weather conditions, and a clear-cut influence of the treatment upon foliage conditions and yield was less evident than in former years. Three types of experiments, covering effective planting dates, effective number of sprayings, and resistant seed selection, were carried on, and commercial experiments on a large scale in several northern counties of Wisconsin are now under way, with a view to ascertaining the variations in treatment necessary on different soil types and under various climatic conditions. Farmers' Bulletin No. 1225, entitled "The potato leafhopper and its control," has been issued and covers the subject in a practical way to date. Work on the potato aphis is nearing completion, and additional facts have been learned in regard to the life history and control of the spinach aphis, the tarnished plant-bug, and flea-beetles on potatoes and related crops.

THE STRIPED CUCUMBER BEETLE.—The control of the striped cucumber beetle from a practical standpoint has been brought near completion through the excellent results obtained by nicotine dusts. A preliminary report has been published showing how this, our most destructive pest of seedling cucumbers, can be controlled by the use of a dust containing 1.6 per cent nicotine. In Wisconsin a combination of nicotine-Bordeaux dust, prepared by spraying nicotine sulphate on powdered monohydrated copper sulphate and lime, secured even better killing than did the nicotine-kaolin and lime mixture, apparently evolving nicotine more slowly and hence acting over a longer period than the usual mixture. The method of application is of the greatest importance to obtain the best results. A good volume of dust thrown quickly and with force to drive the beetles from cracks in the soil about the plants and to reach active individuals which escape by flight has been found necessary.

STRAWBERRY AND BLACKBERRY INSECTS.—Work on the strawberry leaf-roller in New Jersey has been completed during the fiscal year. It embraces a thorough study of the insect's biology in its occurrence in that State and methods for its control. Certain parasites reared

and studied have proved of considerable economic importance. The addition of a spreader, such as lime, gelatin, or fish-oil soap, was determined to be essential in control by arsenicals, since on strawberry foliage the under surface, which must be reached in order to poison the insect, is strongly pubescent and ordinary sprays applied without a spreader tend to collect in drops instead of giving an even coating. Spraying should be applied as soon as the eggs hatch, because later the larvæ construct protective tents or roll the leaves. Burning and cleaning the fields as soon as the crop is removed is also a measure of importance. A report covering this work is available as a bulletin. Observations and control experiments on the strawberry weevil were continued in the Chadbourn (N. C.) district. The strawberry leaf-beetle (*Haltica litigata*) was the cause of considerable concern in Louisiana, where nicotine dust proved effective. Life-history work on this species has been begun.

SUGAR-BEET INSECTS.—Work on the curly-top leafhopper in co-operation with the Bureau of Plant Industry has continued. The exact limits of overlapping generations have been the subject of cage experiments, and one year's breeding work has been completed. Particular attention has been given to the native flora which might serve as reservoirs for curly-top virus and the relation of filaree and *Chenopodium murale* is also being investigated. The production of resistant seed at Riverside, Calif., through the medium of inoculated stecklings is developing some promising features. Although the plants are inoculated from one to three times, a large percentage of the best selections show normal growth.

NICOTINE DUST AS A MEANS OF INSECT CONTROL.—In previous paragraphs mention has been made of the value of this insecticide and deterrent for specific insect pests affecting vegetable and truck crops. It is hoped that a dust will be developed from which all of the nicotine will be available, since, as at present manufactured, a certain proportion of the nicotine is unavailable, with consequent waste of expensive material.

GENERAL TRUCK-CROP INSECTS.—The Porto Rico mole cricket, recently introduced into South Carolina, has been the subject of experiment with poisoned baits with excellent success. The results of several years' work on blister beetles, important enemies of vegetables and truck crops in the West, have been completed and published.

SOUTHERN FIELD-CROP INSECT INVESTIGATIONS.

Investigations of insects affecting southern field crops have been continued under the direction of Dr. W. D. Hunter.

COTTON INSECTS.—As in preceding years, the work has been centered around the further development of the process of controlling the boll weevil by dry calcium-arsenate dust. Studies in the application of this poison were continued at the various field substations under the direction of the Delta Laboratory. Plat tests were carried through to completion in Mississippi, Alabama, Texas, Georgia, and South Carolina. Much valuable information was obtained in this way as to the modifications of the poisoning system necessary to successful weevil control under varying conditions and in widely separated cotton-growing regions. It was found that in most cases

the system can be adapted in a way to make poisoning profitable under these different conditions on land which normally produces one-half bale or more per acre. Much valuable information was secured also on the exact limitations of profit in boll weevil poisoning.

The development of dusting machinery has been continued. There are now over 40 different machines on the market, practically all of which were previously tested at the Delta Laboratory. Progress is being made on the development of new types of machines suited to conditions for which no machines are at present available. This has resulted in the recent appearance on the market of the so-called saddle gun or mule-back gun. While this machine is still in the developmental stage, apparently it has much promise of usefulness.

The studies on the quality of the various types of calcium arsenate on the market have been considerably elaborated and a cooperative project inaugurated with the Bureau of Chemistry. Methods of manufacture are being studied in order to determine the causes of variations in the completed product in relation to its adhesiveness, ease of distribution over the plant, etc. The investigation undoubtedly is leading to a considerable change in methods of manufacture and a much improved product.

The chemical inspection is being continued as in the past in cooperation with the Federal Insecticide and Fungicide Board. This includes both the examination of unofficial samples of calcium arsenate submitted by county agents and the study of official samples taken by inspectors employed by the Insecticide and Fungicide Board. In connection with the latter type of inspection, evidence for court cases is secured whenever the material is found to be unfit for use.

Studies on the deterioration of stored calcium arsenate extending over a period of several years have just been completed and a manuscript on the subject has been prepared for publication. The investigation has led to important modifications in the kind of containers recommended for the shipment of calcium arsenate, and has done much to standardize the supply. These studies also were made in cooperation with the Insecticide and Fungicide Board.

An interesting development of boll-weevil poisoning is the fact that in some localities the use of calcium arsenate so reduces the natural enemies of the cotton aphid that the latter becomes seriously injurious to cotton. Investigations are being conducted to determine the best method of control of the cotton aphid in connection with control of the boll weevil. Studies are also being conducted bearing on the relation between the use of calcium arsenate and the possible incidental control of the bollworm.

TOBACCO INSECTS.—The most important addition to tobacco hornworm control has been the perfecting of a tandem-wheel shaftless type of one-mule two-row duster for the application of insecticides to the tobacco plant. The work was begun two years ago and was mentioned in the annual report of last year. Since that time more than 200 acres have been dusted with the experimental model with much better results than could have been obtained with hand dusters. As much as 18 acres has been dusted in a single day, about three times as much as could have been done with a hand duster. A patent to be dedicated to the public has been applied for, and already one of the older manufacturers of dusters has begun the construction

of experimental models of this type of machine. The advantages of the shaftless type over the shaft type of two-row duster lie in the fact of the lower center of gravity and the fact that it can be turned in half the space required by the shaft type. It is also thought that the cost of construction will be less than that of the shaft duster.

The most severe outbreak of crambids ("screw worms") on record for this region occurred this year. Many tobacco fields had to be almost completely reset twice. A large number of other fields were so badly infested that two and even three heavy replantings were necessary. Two species were about equally concerned in the injury, *Crambus caliginosellus* and *Acrolophus popeanellus*. A poisoned bait containing an attractant, the first direct remedy on record, was found to give a control of 88 to 89 per cent on *caliginosellus* in some experiments and a control of 86 to 93 per cent in other experiments. However, further experimentation is necessary before exact methods of application should be advised.

The work upon the life history of the tobacco flea-beetle at Quincy, Fla., mentioned in the last report, has shown very satisfactory progress. In addition to three generations in direct line, the number of larval instars has also been determined and control work has been continued and improved upon. The tobacco thrips were scarce again, and nothing more than preliminary experiments with nicotine dusts could be performed.

A preliminary survey of the tobacco-insect problems of the Burley tobacco belt has been made, and a great lack of adequate and economical methods of control found. Arrangements have been made for a few large-scale field experiments upon hornworm control in this region.

SUGAR-CANE AND RICE INSECTS.—The tachinid parasite, introduced from Cuba and released upon various plantations for the purpose of controlling the sugar-cane borer, was found in the fall of 1921 on 18 plantations scattered throughout the sugar parishes of Louisiana. Upon 17 of these plantations it had endured one winter, and in one place it had lived over two winters. It is expected that the parasite will increase at these centers and gradually spread over the entire sugar section.

In addition to the Cuban parasite, specimens of a braconid parasite brought to this country from southern France to control the European corn borer were sent to the sugar-cane insect laboratory at New Orleans. It was not known whether they would attack the sugar-cane moth borer, but they were found to do so readily and to breed on it successfully. These parasites are at present being released at only one plantation, but it is planned to release them generally if favorable results are obtained upon this plantation.

Control work on the moth borer is not confined to parasite introduction, but experiments are being conducted with various chemicals to test their efficiency in killing the larvæ in the seed cane after planting. This work includes tests with paradichlorobenzene, which has given good results in control of the peach-tree borer. A number of chemicals not previously used as insecticides are being tested.

A new lepidopterous larva, boring in sugar cane, has been found along the Mississippi coast, inspections having been made by an agent of this bureau cooperating with the Mississippi plant board.

It was found during the year that the sugar-cane moth borer also damages rice in Louisiana. It probably has been confused heretofore with the rice stalk-borer, which resembles it closely. An investigation of these two pests in their relation to the rice crop has been started.

INSECTS AFFECTING THE HEALTH OF MAN AND DOMESTIC ANIMALS.

SCREW-WORM AND BLOWFLIES.—The investigations on this project have been continued in cooperation with the Bureau of Chemistry and the Texas Agricultural Experiment Station. Extensive experiments have been carried out at several points in Texas to find if possible some satisfactory repellent which may be used to keep screw-worms and blowflies off wounds on animals until they have healed. This has required the testing of a great many substances and many repetitions of the tests. Several very promising chemicals have been found which are to be given extensive tests under range conditions. Attention has been given to finding a less expensive and more stable material than chloroform for killing screw-worms and wool maggots.

It has been conclusively demonstrated that the use of the fly-trap designed by the bureau, in conjunction with carcass destruction, is a very effective method of reducing screw-worm and wool-maggot troubles in the Southwest. Experiments have been continued to find effective dry baits which can be carried on horseback in concentrated form for use in flytraps on the range. Dried egg is giving excellent satisfaction and is more generally available and more pleasant to handle than dried intestinal mucus, which was introduced by the bureau three years ago.

WARBLE OR GRUB.—Studies of the warble or grub of cattle have been continued along lines similar to those reported upon last year. Considerable attention has been given to further studies of the life history and seasonal history of the northern warble, *Hypoderma bovis*, in New York. Further steps have been taken to prepare the people of that section for extensive control work. While the full extent of damage from this pest is not generally recognized by the stockmen and dairymen, they all admit that control or eradication procedure is well warranted. It is believed that such procedure is feasible, as the insect restricts its attack to cattle. It is present in its later larval stages under the hide along the backs of cattle during a few months only of each year, and in this situation it can be destroyed with certain treatments, such as the application to the openings of iodoform 1 part to petrolatum 5 parts. The principal features in the life and seasonal history of the two species of warbles have been determined with sufficient exactness to make it possible to proceed with tests of control methods on a considerable scale.

LICE AFFECTING LIVE STOCK.—Studies of the life histories of the lice, especially goat lice, have been in progress during the winter months, and experiments in cooperation with the Texas Agricultural Experiment Station are under way to determine the best procedure to follow in order to insure complete destruction of all lice by dipping.

INSECTICIDE STUDIES.—Further tests with the little-known insecticide derris have been carried out and the results published. This

material has been found to be very effective for use in the dust form against lice of cattle and other domestic animals, as well as against fleas. The finding of an effective dry treatment for lice is a matter of much importance to the dairymen and stockmen of the North, where the use of sprays or dips is hazardous during the winter, when the lice usually become most troublesome. Thousands of dollars are spent each year for lice powders, and many of these are entirely ineffective.

INSECTS AFFECTING THE HEALTH OF MAN.—The investigation of malaria mosquitoes at Mound, La., has been continued during the year and combines a general biological study of the local species with observations on the effect of certain control measures instituted by the International Health Board.

The field covered by the biological investigation includes: (1) Larval studies—principal breeding areas, conditions favoring maximum production, normal emergence from unit areas, distance from source to food supply; (2) adult studies—normal abundance around dwelling houses, monthly and seasonal variations in abundance, distance of flight, and dispersion of adults; (3) natural control—studies of insect, plant, and fish enemies; and (4) dissection of adult *Anopheles* to determine percentage of infected mosquitoes in nature and their distribution.

The study of experimental control measures carried out in cooperation with the International Health Board includes: (1) An experiment to determine the effect of collections of adult mosquitoes inside houses; (2) effect of screening the ordinary tenant house upon malaria incidence and *Anopheles* abundance; (3) effect of clearing and impounding a 3-mile section of a natural bayou; and (4) effect of moving tenant houses to more favorable locations, an investigation which includes a general study of the influence of location on malaria incidence and *Anopheles* prevalence.

During the year a series of enlarged photomicrographs of different stages of malaria infection in the mosquito host was exhibited at the Hot Springs (Ark.) meeting of the Southern Medical Society. A preliminary paper on normal abundance of *Anopheles* around tenant houses was read before the New Jersey Mosquito Association and published in the proceedings of their society.

INSECTS AFFECTING FOREST RESOURCES AND SHADE TREES.

This work has been continued under the direction of Dr. A. D. Hopkins.

INSECTS AFFECTING FOREST TREES.—The work at the field stations in California and Oregon, and in the northern and southern Rocky Mountain States has been almost entirely in response to requests by the Forest Service, National Park Service, and private owners for examination and report on infested timber and cooperation in conducting control projects.

THE SOUTHERN OREGON-NORTHERN CALIFORNIA CONTROL PROJECT.—One of the most extensive control operations against a tree-killing insect ever undertaken is that of the southern Oregon-northern California cooperative control project. Continued and increasing depredations by the western pine beetle on the yellow-pine timber on more than 1,300,000 acres of National Forest, Indian reservation, and pri-

vately owned lands in Klamath County, Oreg., and Modoc County, Calif., led to a combined request for a survey and report by this bureau. Following the report Congress appropriated \$150,000 to be expended by the Departments of Agriculture and Interior, in cooperation with private owners and the State of Oregon, in conducting control operations on this area under the supervision of representatives of this bureau through a board of control. A cooperative organization was effected under an agreement between the two departments—Agriculture and Interior—and the private owners represented by the Klamath Forest Protective Association. Control crews and camps were organized and work was started in May and completed June 15, 1922. Seven thousand and seventy-nine infested trees, representing 6,672,490 board feet, on an area of 68,620 acres, were felled and barked, and the bark burned, at a total cost of \$30,433.63. Approximately \$4,000 has been expended on this project from the bureau allotment and a considerable amount was expended in making preliminary surveys from the regular appropriation for forest insect investigations.

THE ANTELOPE CONTROL PROJECT.—The Antelope project is located in northern California on privately owned lands; the cost of the work was paid by the owners, and the supervision was by a representative of the bureau at the Ashland, Oreg., station. On this area 3,200 trees were treated in 1921 and 1,765, on about 10,500 acres, were treated in 1922.

THE SAN JOAQUIN RESEARCH AND CONTROL PROJECT.—The San Joaquin project in California includes both research and control work in cooperation with the Forest Service. The principal control work was completed in 1919, but experiments and studies, with reference to methods of maintaining control, have been continued from our field station at North Fork, Calif.

FIGUEROA CONTROL PROJECT.—This project is in the Santa Barbara National Forest, Calif., and was conducted in cooperation with the Forest Service. Sixty-four trees infested by the western pine beetle on 2,400 acres were treated, at a cost of \$200 to the Forest Service and about the same to this bureau.

ARROWHEAD LAKE CONTROL PROJECT.—This project is located in the San Bernardino Mountains of California, embracing an area of about 5,000 acres of privately owned and about 3,000 acres of National Forest land. The work was conducted by the private owners under the supervision of representatives of this bureau. Twenty yellow pine and 44 Coulter pine trees infested with the western pine beetle were treated, representing a volume of 77,030 board feet, at a cost to the private owners of \$304.

GRAND CANYON-KAIBAB CONTROL PROJECT.—This is a cooperative project between the Forest Service, Park Service, and Bureau of Entomology, on an area 8 by 28 miles, in the Grand Canyon National Park and Kaibab National Forest, Ariz. Five thousand six hundred and eighty-three pine trees, representing over 1,000,000 board feet, infested by the Black Hills beetle were treated, at an approximate cost of \$7,150 to the Forest Service, \$1,180 to the Park Service, and \$2,700 to the Bureau of Entomology.

SURVEYS AND REPORTS.—In addition to the responses to requests for surveys and reports on Government and privately owned timber

included in the above-mentioned control projects, the following made during the year may be mentioned:

Six national-park areas in Idaho and two in Montana were examined and reported upon for the Forest Service, one for Forest Service and private owners, one for private owners in Idaho, and one for the Klamath Indian Reservation in Oregon. These surveys showed that in Idaho and Montana the infestation and timber killed by the western pine beetle and the mountain pine beetle continues about the same as the average in past years, causing in the aggregate a great loss of the best white pine, yellow pine, and lodgepole pine, and that in several places epidemic infestations prevail, especially in the lodgepole pine.

A wind-blown area north of Fort Klamath, Oreg., was examined for private owners. It was estimated that a loss of some 6,000,000 feet had been caused by the wind in November, 1921, but that so far it has not resulted in an expected epidemic of the western pine beetle.

FOREST PRODUCT INSECTS.—Investigations and experiments relating to methods of preventing losses from wood-borer damage to crude, rough, seasoned, finished, and utilized forest products have received special attention through cooperation with manufacturers in Georgia and Virginia. This has consisted of experiments and practical demonstrations with the application of chemicals to sawlogs, submergence in water, treatment of seasoned wood, and methods in general management to prevent losses.

SHADE TREES AND ORNAMENTAL SHRUBS.—The work on the insects of this character has been mainly done in Washington, D. C., and in California. The correspondence has been very large, and the bureau has been of much assistance to many towns and cities. Considerable work was done in California from the field stations at Palo Alto, Los Gatos, and Chico, on the Pacific flat-headed borer, defoliating caterpillars, live-oak leaf-gall, mealybug on citrus shade trees, the cypress bark scale, grasshopper defoliation of roadside trees, etc. Work was also continued on the cable beetle, which causes such serious damage to lead telephone cables in California.

FIELD RESEARCH.—The greatly increased demand for cooperation with Federal officials and private owners in the Pacific and Rocky Mountain States has been such as to interfere seriously with work on research problems, the solving of which is of special importance as a basis for up-to-date advice and assistance relating to economy and success in the control and prevention of epidemics by tree-killing and wood-destroying insects. Considerable progress, however, on some of these problems was made in connection with the cooperative-control projects.

RESEARCH WORK AT WASHINGTON.—The research work carried on by experts on forest insects and related problems, which is so essential to successful field work, has been continued, but with a reduced force. In addition to the identification of species, this work has related particularly to the study of beneficial insects and the immature stages of both beneficial and injurious species, in order that they may be identified from any stage or even from fragments of the insects or specimens of their work, all of which is contributing to a marked advance of the science of forest entomology.

Work on the relation of climate to insects and other life under the new science of bioclimatics has been continued, both at Washington and at a temporary field station in West Virginia.

PRINCIPAL RESULTS.—The most important result of the year is one for which we have been striving for many years, namely, increased interest and confidence in the work of the branch of forest entomology and its recommendations. This is now manifested in a most gratifying way by National Forest, National Park, and Indian reservation officials, and especially by representatives of some of the principal private owners of timber and manufacturers of forest products. There is a marked increase in requests for information and advice and for our cooperation in dealing with some of the big problems involving the loss of standing timber and forest products. It is becoming recognized, especially in the West, that forest entomology is an essential phase of forest conservation. The increased interest and confidence are also shown in the fact that within the closing months of the fiscal year, over 1,400,000 infested trees, representing more than 8,000,000 board feet of timber, were treated according to the recommendations and under the supervision of representatives of this bureau, at a cost of over \$46,000.

Inspection of areas on which control work was done during recent years showed most gratifying results in the ending of the epidemics and consequent saving of a great quantity of timber. Among other results that may be mentioned are:

(1) Verification of the principle of continuous logging operations as a means of preventing epidemics of tree-killing insects.

(2) Evidence that the epidemics of tree-killing insects do not come in regular but in irregular cycles.

(3) Demonstrations of the importance and economy of cooperative insect-control work.

(4) Evidence that hardwood submerged in water, as sawlogs or as lumber, is immune against powder-post attack after the wood is seasoned.

(5) The discovery in practical tests that liquid orthodichlorobenzene is effective in killing borers after they have entered the wood, and that paradichlorobenzene dissolved in kerosene gives similar results.

(6) Practical tests of the solar-heat method of killing insects in the sapwood of sawlogs and of preventing attack show that under certain conditions it is both practical and effective.

(7) *The management principle* of preventing losses from insect depredations, as related to damage to forest products, defoliation of fir and spruce by the spruce budworm, and tree-killing insects in general, is becoming recognized as of fundamental importance in lumbering operations and general forest conservation.

BEE-CULTURE INVESTIGATIONS.

The work of the bee-culture laboratory, under the supervision of Dr. E. F. Phillips, has been conducted along the same general lines outlined in the report of last year, namely, the emphasis of investigational work rather than educational work such as was conducted during the war. The projects under which this work is

done were revised at the beginning of the fiscal year and the work is here reported under the new projects.

BEHAVIOR OF BEES.—Work has been begun on a study of the temperature and humidity conditions in all parts of the hive during the active season. During the latter part of the active season of 1921, temperature and humidity records were made hourly during the day, with occasional periods when records were made at night and day for several days at a time. Careful records are made of the plants that are furnishing nectar and pollen and of the hourly weights of the hive under observation. This work continued without interruption until early June, 1922, at which time certain difficulties were encountered with the thermocouples and it was necessary to discontinue the work for a short time in order to rewire the hive. The work will be continued throughout the active season of 1922. It is too early at this time to summarize the results of this work, but there can be little doubt that it will result in a better understanding of the temperature and humidity conditions prevailing in the hive during the summer. This in turn may, as in the case of the wintering work, lead to important modifications of the hive or of its management, and in any event will help to make clear the reasons for some of the phenomena which beekeepers have long observed but have not understood.

The work on the rate of increase and decrease in brood rearing is being continued.

In June, 1922, a study was begun on the responses of bees to lights of various colors and intensities. It has long been known that bees respond to numerous light stimuli, but so far no detailed study has been made on this subject, aside from some work on the responses of bees when their sight was impeded. Numerous experiments have been made on the preference of bees for certain colors, which have shown conclusively that they recognize color differences. It is hoped that the present work will clear up some of the uncertainties in this field.

At the opening of the active season of 1922, a study was undertaken of the flight of bees to and from the hive, as modified by temperature, light, the secretion of nectar, and various other external factors. This work is being done by A. E. Lundie, of South Africa, who is spending some time in the United States in a study of beekeeping. He has devised an ingenious apparatus by which the movements to and from the hive may be accurately counted automatically, and this has been installed for several months. Records of outgoing and incoming bees, of the weight of the hive, and of the temperature and other external conditions are made every quarter hour from daylight until dark daily. It is hoped that the results of this work will throw some light on certain details of bee activity so far not clearly understood.

The ability of queen bees and drones to feed themselves, without the intervention of worker bees, was established in some recent feeding experiments. While under hive conditions both the queen and drones are usually fed by the workers, they are both capable of taking food independently of the workers.

PHYSIOLOGY OF BEES.—In connection with the study of the wintering problem several years ago some feeding experiments were undertaken to determine what carbohydrates are available to bees as food,

in an effort to explain the phenomena of dysentery (spotting of feces) so frequently observed when bees are not wintering well. At that time it was learned that bees are unable to digest certain carbohydrates which are found in inferior grades of honey and in honeydew honey, and these results were incorporated in publications on wintering. The subject required additional experimentation before definite statements could be made concerning certain interesting carbohydrates, and during the spring of 1922 additional feeding experiments were undertaken. A large series of chemically pure carbohydrates were obtained and fed to bees to determine their availability as food. Most of the materials chosen were those which bees might obtain in the gathering of nectar in the flowers. It is now evident that the ability of bees to digest carbohydrates is exceedingly limited. The results obtained explain fully the cause of dysentery in winter and emphasize the need of great care in the choice of winter stores. When bees are free to fly during the summer any of these materials which they can not digest will be eliminated through the feces; but during confinement to the hive this is impossible, and the condition known as dysentery results, often followed by the death of the entire colony. Methods for the prevention of this condition have been incorporated in publications of the department dealing with wintering of bees.

Tests have been made of the insulating value of various commercial double-walled hives on the American market to determine their suitability for wintering. The results of this work have been presented for publication as a circular of the department.

The results of the experiments on wintering bees have been further worked up. There still remains considerable work to be done before the full results of the experiments on wintering bees are available for publication, but we hope to submit them in a few months.

The work on the factors influencing the aging of bees which was mentioned in the last report was discontinued at the close of the summer of 1921, but was again undertaken in the spring of 1922. For the present, attention is being given especially to the changes which occur in the oenocytes in the adult worker bee. The purpose of this work is to determine the changes which occur in bees when they wear themselves out by excessive activity, especially during the winter months, when they are confined to the hive, and it is hoped that when these phenomena are understood, remedies for the great losses caused by the death of the worn-out bees may be devised.

As was stated in the previous report, some samples of supposedly poisonous honeys were obtained and submitted to chemical analysis. This work failed to show the cause of the trouble, and during the spring of 1922 an effort was made to determine the plant which furnished this honey. In cooperation with the Bureau of Plant Industry, it has been found to be the mountain laurel. It still remains necessary by chemical analysis to determine the presence of the poisonous material in the honey. It is of the greatest importance also that a study be made to determine under what conditions this plant secretes nectar which is poisonous, for it seems evident that it does not always do so, since the plant has a wide distribution and poisonous honey is not commonly produced. The chemical work on this honey will be undertaken as soon as possible.

In connection with the wintering work several years ago, it was found that the darker grades of honey are not as a rule as satisfactory as lighter honeys for winter stores. The grading of extracted honeys according to color is also a serious problem in honey marketing, and so far no satisfactory color grades have been established, although several attempts have been made by private individuals. An attempt to bring about a satisfactory grading is now being made, in cooperation with the Office of Grades and Standards, Bureau of Agricultural Economics. It is also hoped that typical samples may be subjected to chemical analysis to determine to what extent color is associated with undesirable characteristics for winter food. The samples will also be examined to identify the pollen grains contained in them, thus checking up the statements of those furnishing the honeys as to the floral source. If these samples may be adequately studied, it will constitute the most comprehensive investigation of American honeys so far made.

DISEASES OF BEES.—The announcement of the cause of the Isle of Wight disease of adult bees, made in December, 1920, by Dr. James Rennie and his associates, of Scotland, has greatly increased the interest in the diseases of adult bees throughout the world. During the summer of 1921, as was stated in the last report, a study was made to determine if possible whether the mite (*Tarsonemus*) *Acarapis woodi*, causing this disease, is present in the United States. The results of the study were published as Circular 218 of the department.

As a result of a conference, held March 9, 1922, a letter was written to the Post Office Department recommending that the regulations on foreign mails be amended to exclude queen bees and the accompanying worker bees from all foreign countries, except Canada. The Dominion of Canada had also taken steps to prevent the importation of all adult bees from Europe, and since there are no known cases of the Isle of Wight disease in the Dominion, there seemed no reason to prevent the free passage of bees between the two countries. Similar quarantines are established in Australia, Jamaica, and the Union of South Africa. Since the publication of Circular 218, records have been published of the presence of the disease in several parts of France, Switzerland, and Germany, and new records of the disease appeared every month during the early part of 1922. It is impossible at this time to predict the full distribution of the disease, and for the present it seems wise to prevent the importation of all adult bees from all European countries. Considerable work is now being done in Europe on this disease, and it may be possible later to recommend a further change in the regulations to permit importations from certain countries which are known to be free of this serious disease.

Following the conference on March 9, a bill was prepared for presentation to Congress prohibiting the importation of of adult bees, except for experimental purposes by the Federal Department of Agriculture and except under rules and regulations made by the Secretary of Agriculture and the Secretary of the Treasury to permit the importations from countries known to be free of any disease dangerous to adult bees. The bill was presented to both Houses of Congress, and was passed by the House of Representatives on June 5. At the present writing it is still before the Senate Committee

on Agriculture and Forestry. The chief purpose of this bill, which has the indorsement of the department, is to regulate the importation of adult bees by means other than the mails, since such importations have been rather frequent in the past. In the event that this bill becomes law it will be possible to modify the regulations from time to time as importations from certain countries are found to be necessary and safe. It will further be possible to obtain, under the provisions of this bill, importations from any country which are needed to improve the breeding stock of the United States, and at the same time to prevent the importation of the mite causing the Isle of Wight disease.

During the present summer (1922) a large number of samples of adult bees are being received and examined for the presence of the mite, and up to the time of this writing no specimens of the mite have been found in bees from the United States. This study is greatly increasing the information available regarding other diseases of adult bees in the United States.

Work on the brood diseases of bees is being continued. During the past fiscal year 1,056 samples of suspected material were received, in which were included 200 samples of adult bees. This number is slightly smaller than that for the previous fiscal year, but is much larger than for most years since samples of diseased material have been received by the laboratory. There is an increasing need for beekeepers and apiary inspectors to have laboratory diagnoses of doubtful material, and it is believed that the examination of such material is one of the most important services which the bee-disease work of the laboratory provides for beekeepers.

The investigational work on the diseases of the brood of bees has consisted chiefly of a biochemical study of healthy and diseased brood in an effort to devise more suitable media for the study of the causes of the brood diseases. So far it has not been possible to grow *Bacillus pluton*, the cause of European foulbrood, on artificial media, a thing which is badly needed in a study of this disease. Some progress has been made in improving the media used in cultivating *Bacillus larvae*, the cause of American foulbrood. The study of the composition of the larvæ at different ages has served to explain fully the differences in the behavior of the two important brood diseases with relation to the age of the larvæ attacked by them.

The study of the factors influencing the distribution of European foulbrood, to which reference was made in the last report, has been continued, but it has been found necessary to clear up certain undetermined factors regarding the honey flows from various plants before publishing the results, and this has made it necessary to delay publication. It is still found to be true that certain important beekeeping regions of the United States are free of this disease, because of the character of the honey flow, and the results probably constitute the most important advance which has been made in the control of this disease, which has caused such great losses to American beekeeping.

Regulatory work for the control of the brood diseases of bees has always been handled as a State function, and there are now laws or regulations regarding this in 35 States and in Hawaii and Porto Rico. A gradual but definite change is taking place in this work, in that it is becoming more and more educational in character. The

control of European foulbrood by the exercise of police power is unsatisfactory, and even for American foulbrood there is a tendency to eliminate the regulations formerly thought essential. In this change the bureau has worked merely in an advisory capacity, but it has been the policy for a decade to emphasize the importance of educating the beekeeper, and this is bearing fruit.

BEEKEEPING REGIONS OF THE UNITED STATES.—The three Farmers' Bulletins on specific beekeeping regions of the United States, mentioned in the last report, have been published as follows: Farmers' Bulletin 1215, "Beekeeping in the clover region"; Farmers' Bulletin 1216, "Beekeeping in the buckwheat region"; and Farmers' Bulletin 1222, "Beekeeping in the tulip-tree region."

A tabulation of the percentages of the commercial honey crop of the United States from introduced and native plants has been made. It is found, curiously enough, that about half of the commercial honey crop of the country is derived from plants that have been introduced and that about three-fourths of the crop comes from plants which are not native to regions originally inhabited by the honeybee.

DEMONSTRATIONS IN BEEKEEPING.—The work on this project, which occupied so large a part of the bee-culture work during the war, has been still further decreased during the past year. At present the office is cooperating with three States in the maintenance of extension specialists in beekeeping.

It is interesting to note that in almost all the States where extension work in beekeeping was begun during the war the work has been continued as a State project and there has virtually been no decrease in work of this kind, in spite of the necessity for curtailing the activity of the bee-culture office in this line. The work has proved so helpful to the beekeepers of the various States that it has been virtually impossible for the extension divisions of the various States to drop it.

The extension short courses which were so widely held immediately following the war have to a large degree been dropped. During the past year four such schools were held—two in Colorado, where no such schools had been held previously, and two in California. While it has been impossible to conduct more of these schools, they have been received so enthusiastically by the commercial beekeepers in attendance that it is evident that they fill a great need.

While there have been associations of beekeepers for many years for a discussion of their problems and an interchange of ideas, organizations for the cooperative selling of honey have been developed recently to a large degree in the Western States, to the advantage of the beekeepers of the regions covered. Organization work of this character is now extending into the East.

MISCELLANEOUS ACTIVITIES.—Several articles for bee journals and other publications have been prepared during the year on subjects which do not deal directly with the investigations of the laboratory or of results which were not suitable for publication by the department.

STATUS OF BEEKEEPING.—The change in the status of beekeeping outlined in the last report is still manifest. The drop in honey prices following the close of the war brought on a serious situation

for the beekeeping industry of the country, and in the fall of 1921 the honey market of the country was in a deplorable condition, due to the great increase in production since 1917 and to the economic condition of the country. An interesting development arose from the fact that the majority of the beekeepers of the country were unable to sell their 1921 crop through the usual wholesale channels, and to prevent a total loss many of them undertook to sell directly to consumers. More honey was sold in this way during the fall and following winter than ever before in the history of American beekeeping, and the prices obtained for the honey were much better than could have been obtained in the usual markets. This method of selling also resulted in many people buying honey who did not do so previously, and in this way much permanent good resulted to beekeeping. The rather remarkable results are shown by the fact that not only was the whole of the 1921 crop sold, but a considerable amount of honey left over from 1920 also disappeared. There was little help from manufacturers, who sometimes use honey in the making of cakes and candies, and the housewives of the country used the honey which was sold. This offers a ray of hope to the specialist beekeeper who fears the changes in wholesale prices, in that he has found it possible to sell large crops directly to the consumer. While there will doubtless be an increase in the facilities for handling honey at wholesale, and perhaps a still larger increase in the bottling of honey by commercial establishments, it is comforting to the beekeepers of the country to know that they are largely independent of such development.

INSECT PEST SURVEY.

J. A. Hyslop has continued in charge of this branch of the bureau's work since its inception in March, 1921. The survey has now been in operation 16 months. It has filled the need that has long been felt among entomological workers for a medium through which they could be kept more closely in touch with the insect conditions in the various parts of the country, and for a permanent record of these conditions correlated with the prevailing meteorological conditions from year to year.

During 1921 the survey completed Volume I of its monthly bulletins, which consisted of 7 numbers and an index. Volume I contained 285 pages of subject matter with a 31-page index. Five numbers of Volume II have already been issued and the annual summary of the insect conditions throughout the United States for the year 1921 is now in press. The annual summary contains 51 pages of subject matter illustrated with 28 text figures showing the geographical distribution of the insects discussed and the meteorological conditions associated with the several outbreaks reviewed.

During the year over 6,000 notes have been received on insect conditions. These notes relate to 716 different species of insects representing 567 genera.

The work of the survey has attracted considerable attention not only from entomologists but from produce exchanges and information bureaus on produce futures. The agricultural press is also utilizing the information made available by the survey.

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